A model-based theory of omissive causation

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Abstract

Current psychological accounts of causal representation and reasoning do not capture phenomena related to causation by omission (e.g., "The absence of breathing causes death"), with one exception (Wolff, Barbey, & Hausknecht, 2010). We describe a novel theory of omissive causation that posits that people build discrete mental simulations – mental models – of causal relations (Goldvarg & Johnson-Laird 2001). The theory states that causes by omission refer to a set of temporally ordered models of possibilities. Reasoners tend to focus on only one of those models, i.e., the possibility in which breathing does not occur and death subsequently does. Likewise, the theory posits that reasoners distinguish between omission in the context of causation, enabling conditions, and prevention. We describe some initial predictions made by the model-based account, contrast it with an alternative psychological theory based on the transmission of causal forces, and set out directions for further research.

Keywords: omissions; absences; causal reasoning; mental models; negative events; double prevention

Introduction

A woman from Cincinnati, Ohio, was recently awarded $1.2 million in a malpractice suit (Hunt, 2014). The jury found her doctor guilty of malpractice concerning his negligence in adequately diagnosing her abdominal pain. Her doctor did not give her a CT scan until she was critically ill, i.e., suffering from acute respiratory distress syndrome. The jury concluded that not diagnosing her illness in a timely manner had a permanent, debilitating effect on the woman's life: she is unable to move without a walker as a result of her breathing difficulty.

When a doctor is a defendant in malpractice litigation concerning negligence, the central issue concerns omissive causation: did a failure to perform one or more actions adversely affect the doctor's patient? Omissive causation, more generally, concerns a causal link between a failure of an event to occur and the consequences of that failure (see Paul & Hall, 2013). Issues concerning causation by omission are prevalent in healthcare, public policy, and legal fields (Ferrara, 2013), where the costs of a failure to act have monetary and legal consequences. The ontological issues undergirding those discussions are a topic of controversy among philosophers, who are concerned with the peculiar sorts of problems that omissive causation generates. Omissions are deeply problematic when treated within standard theoretical frameworks for understanding causation. The problems are so severe that some philosophers have even suggested carving up causation into two distinct concepts in order to accommodate omissions (Hall, 2004). The problem vexes psychological and cognitive theories of causation too, and few researchers have tackled the subject either experimentally or theoretically.

Our goal is accordingly to develop a new theory of causation by omission. We begin by reviewing the philosophical and psychological challenges that omissive causation presents, and describe a recent theory based on the transmission of causal forces that was designed to overcome some of those problems (Wolff, Barbey, Hausknecht, 2010). In light of some dilemmas facing the force theory, we describe an alternative account of causation based on mental models. Mental models represent possible states of the world, observed or imagined (Goldvarg & Johnson-Laird, 2001). Our theory relies on the assumption that people build discrete mental simulations to understand causal relations (Khemlani, Barbey, & Johnson-Laird, 2014), and we apply that analysis to issues concerning omissive causation. We derive several predictions of our account and contrast them with those from the force theory. Finally, we end with a discussion of outstanding issues and plans for future research that may further differentiate our new account from the force theory and other competitors.

Omissive causation in philosophy

Philosophical theories of causation fall into two distinct categories: dependency theories and process theories. Dependency theories interpret causation as concerning statistical (Skyrms, 1980), counterfactual (Lewis, 1973), logical, or structured probabilistic (Halpern & Pearl, 2005) dependencies. In counterfactual dependency models, for example, *A causes B* is equivalent to the following counterfactual assertion: *if A hadn't occurred, then B wouldn't have occurred*. Process-theoretic approaches, in contrast, treat causation as being understood by way of contact and transfer of quantity, such as energies, forces, and masses (Dowe, 2000; Salmon, 1994). Process theories often make specific claims about the vehicle or mode of causation, whereas many dependency theories do not.

Both dependency and process theories of causation have trouble accounting for omissive causation. The most glaring issue for process theorists is that there can be no transfer of quantity in the case of an omission. For example, consider the following vignette (adapted from Paul & Hall, 2013):

1. Billy decides not to take any medicine and falls ill.

It seems as if Billy's refusal to take medicine is the cause of his illness. But there does not appear to be any energy, force, or mass that is conserved or transferred between the subject and the object of the causal relation.

As dependency theories do not make claims about the mode of causation, omissions can be causes. An omission can be interpreted as a probability, a counterfactual situation, a logical relation, and so forth. The trouble with adopting this kind of ecumenism is that it overprescribes causes in a manner at odds with intuitions. Consider the following vignette:

2. You come home after a business trip to find your rosebushes desiccated and ruined. You learn from your neighbor that your gardener did not show up to water the plants.

Our intuitions might suggest that the gardener caused the flowers to die by not showing up to do his job. And indeed, the causal relationship is transparent in light of the counterfactual dependency theory, in which the following analysis is felicitous: *if the gardener had done his job, your flowers would not have died*. What about your neighbor? She too could have watered the flowers and prevented them from dying. Is her omission a cause of the flowers dying? Perhaps it is, but perhaps not. Philosophical theories based on dependencies lack an appropriate mechanism to restrain causation from being applied liberally in cases of omission. McGrath (2005) observes that dependency theories predict far more causation by omission in the world than instances of active causation. There are no widely adopted solutions to this problem of profligate omissive causes. Recent theorists have augmented dependency theories with normative considerations to determining the most intuitive cause of an outcome with multiple putative causes, following suggestions originally made in Hart and Honoré (1985). For example, a counterfactual dependency theory that imported normative principles might posit the following extension: "in the absence of abnormal conditions, if A hadn't occurred, then B wouldn't have occurred" (Halpern & Hitchcock, 2014). Just what constitutes normality may be a deeper and more elusive concept. We turn next to psychological treatments of causation and omissive causation.

Psychological theories of causation

For philosophers, a productive theory of causal reasoning and omissive causation is one that can characterize the states in the world that correspond to causal scenarios. For cognitive scientists and psychologists, the focus is on how human minds grasp and manipulate causal relationships. The enterprise is descriptive rather than prescriptive. A fundamental psychological assumption is that mental resources are finite. Accordingly, it is impossible for reasoners to consider the infinitude of omissive and incidental causal judgments that may be possible granted certain ontological commitments, just as it is impossible for people to represent quantified expressions, e.g., "All the morticians are venal", as sets of infinite elements, and sets of those sets (Partee, 1979). Psychological theories of causation accordingly focus on how people mentally represent, compose, and reason with causal relations given a limited cognitive bandwidth. The kind of causal profligacy that follows from philosophical dependency theories in the case of omissions does not vex psychologists. Instead, the challenge in psychology is to solve the inverse problem of deciding what information reasoners take into account when deducing or inducing a causal relation and how they go about representing and reasoning about such relations.

Psychologists disagree about the mechanisms and representations that underlie causal reasoning (Sloman & Lagnado 2015). Like philosophers, some psychologists align with dependency theorists insofar as they focus on causal model structure (Sloman et al., 2009) and mental models of possibilities (Goldvarg & Johnson-Laird, 2001). Others are more akin to process theorists, and appeal to the transmission of force to explain causal reasoning (Wolff, 2007).

Perhaps because of the pressing challenge of reconciling omissive causation with the transmission of causal forces, Wolff and his colleagues proposed the only known psychological account of omissive causation (Wolff et al., 2010), an extension of an augmented process theory of causation called the force theory (Wolff, 2007). We describe the theory and its account of omissive causation in the following sections.

The force theory

The force theory posits that individuals build mental simulations of interacting entities. The theory represents their interactions as vectors between an *affector* (usually the subject of a causal assertion), a *patient* (usually the object of the assertion), and an *end state* (the causal effect of the affector on the patient). The vectors represent directions and magnitudes of interacting causal forces based on three parameters: i) the tendency of the patient towards an end state; ii) the amount of concordance between the affector and the patient; and iii) progress toward the end state. Consider the following causal statement:

3. Beard trimmings caused the sink to clog up.

In the force theory, the affector would be the trimmings, the patient would be the sink, and the end state would be the clogged state of the sink. In the absence of the trimmings, the sink has no tendency to be clogged. The trimmings acted against the sink being open (and not in concordance) and the sink ended up clogged as a result of the trimmings. The three parameters used to build vector representations would be parameterized for (3) as follows: i) there is no initial tendency of the sink towards the state of being clogged; ii) there is no concordance between the sink and the trimmings; and iii) the trimmings move the sink towards the state of being clogged. This parameterization yields a vector diagram as depicted in Figure 1a. Other causal relations, such as enabling conditions and prevention, rely on different permutations of the forces described (Wolff, 2007). For example, the prevention relation is depicted in Figure 1b.

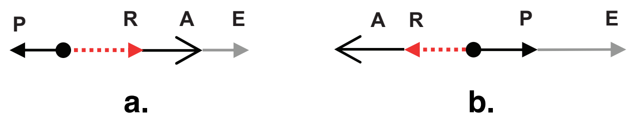

Figure 1. a.) The vector diagram (adapted from Wolff et al., 2010) depicting the causal relationship described in (3). The patient force **P** (the sink), is pointing in opposite direction from the end state position, **E** (being clogged), which indicates that the sink has no tendency towards being clogged. The affector force **A** (the trimmings) is combined with P to yield a resultant vector, **R**, which shows that A moves P towards the end state. When reasoners build up the R vector, they can conclude that because of the trimmings, the sink will eventually get clogged. b) The vector diagram depicting a prevention relationship, as in: *The trimmings prevented the sink from being open*. This situation is analogous to the causal one, except that the initial force of the patient (the sink) is towards the end state (being open), and the affector acts to reverse that tendency.

The force theory's account of omissions is that they are embedded within double preventions:

> "…absences are causal when the removal or nonrealization of an anticipated force leads to an effect. …consider a situation in which a car is held off the ground by a jack. A man pushes the jack aside—removing the force holding up the car—and the car falls to the ground. This situation instantiates a type of causation by omission, as indicated by the acceptability of the description 'The lack of a jack caused the car to fall to the ground.' …[We propose] that causation by omission is always embedded within a double prevention and that it names the relationship between the second and third entities involved. In double preventions, the second entity is removed, and so the relationship between the second and third entities concerns what happens to the third entity in the absence of the second entity." (Wolff et al. 2010, p. 193)

That is, the force theory interprets causation by omission, as in *the absence of A causes not-B*, as *X prevents A* and *A prevents B*. Concordant accounts of omissive causation by double prevention exist in philosophy (Collins, 2000; Dowe, 2001; Hall, 2000, 2004). Two elements distinguish the force theory, however: first, it incorporates double prevention into a theory concerning the transmission of force, and second, it provides an explanation of how to compose two force-based prevention relationships to yield an omissive causation relation. The theory predicts that some instances of omissive causation should yield an arrangement of forces akin to a causal relation, and other instances should yield an arrangement of forces akin to an enabling condition (see Wolff et al., 2010, p. 198).

The force theory is unique in its proposal to capture omissive causation. But it faces two overarching challenges. First, the theory assumes that omissive causation is a result of "the removal or non-realization of an anticipated force" (see above). The force theory assumes an anticipated force, X, in the double prevention: *X prevents A* and *A prevents B*. That anticipated force may be easy to identify in physical examples, such as the one the authors offer concerning the jack and the car. It is much more difficult to identify anticipated forces such as in the medical malpractice example given in the introduction. To apply the force theory to the scenario, a prior force must be assumed and removed to cause the patient to suffer. One would have to interpret the mental state of the doctor, or the professional obligations of his job, or the Hippocratic oath to help those who need it, as a force vector along with the forces at play as a result of his professional acumen. The theory also has trouble dealing with the vignette provided in (1) concerning Billy's refusal to take his medicine. It is not clear how to annotate the vectors with appropriate magnitudes: we might amend the scenario such that Billy merely forgot to take his medicine or else that he was strongly inclined against taking his medicine. The latter implies a larger magnitude, but it does not change our intuitive expectations over Billy's sickness. He does not get more or less sick depending on the reasons for not wanting to take his medicine. The theory would need to appeal to extra-theoretical mechanisms to solve the problem of magnitude assignment (pace Wolff et al., 2010, p. 214). The application of the theory to abstract domains, particularly those involving social interactions, may conflate reasons with causes (Davidson, 1963).

A second challenge is that the force theory's mechanisms for composing double preventions yield a curious result: omissive causes can be interpreted as enabling conditions ("allowing" relationships). As the theory predicts: "in the absence of clear knowledge of the magnitudes, double preventions will be most naturally described as ALLOW relations" (Wolff et al., 2010, p. 198), and the authors present evidence that corroborates the prediction. But consider again the case of omissive causation in (1). Because the vignette does not include any mention of force magnitudes, the force theory should predict that reasoners might conclude that Billy's refusal to take his medicine *allowed* him to fall ill. But the conclusion strikes us as too weak and permissive. Billy's refusal did not *allow* his sickness; his refusal caused it.

As a result of these concerns, we developed an alternative theory account of omissive causation based the construction and manipulation of mental models (Goldvarg & Johnson-Laird, 2001). The theory shares an underlying assumption with the force theory: reasoners build, compose, and inspect mental simulations when reasoning about causal scenarios. But it posits that instead of representing forces and magnitudes, reasoners represent discrete possibilities. Furthermore, it does not base omissive causation on double prevention. In the next section, we describe the general tenets of the theory and how it handles omissive causation.

Mental models and omissive causation

The mental model theory of reasoning – the "model" theory, for short – pertains to reasoning across many domains, including reasoning about temporal, spatial, causal, and abstract relations (Goldvarg & Johnson-Laird, 2001; Goodwin & Johnson-Laird, 2005) and reasoning based on sentential connectives, such as *if*, *or*, and *and* (Johnson-Laird & Byrne, 1991). The theory is built on three main principles (Johnson-Laird, 2006):

1. Mental models represent *possibilities*: a given assertion refers to a set of discrete possibilities that are observed or imagined.
2. The principle of *iconicity*: Mental models are *iconic* as much as possible: the model's structure is isomorphic to the structure of what it represents (see Peirce, 1931-1958, Vol. 4). But, models

can also include abstract symbols, e.g., the symbol for negation (Khemlani, Orenes, & Johnson-Laird, 2012).

3. The principle of *truth*: mental models represent only what is true and not what is false. More models mean more processing difficulties – reasoners make errors more frequently and take longer to draw conclusions when they need to keep multiple models in mind to solve a problem. And they overlook possibilities that render a given statement false.

The model theory distinguishes between *mental* models – models of an assertion that represent only those possibilities that render the assertion true – and *fully explicit* models – those that include additional possibilities that capture situations in which the premises are false. We focus on the model theory's application to causal reasoning (Goldvarg & Johnson-Laird, 2011). The theory distinguishes between different causal relations – such as *cause, enable*, and *prevent* – by positing that those relations refer to distinct sets of possibilities, i.e., distinct fully explicit models. Consider a causal assertion such as: *Spraying a flower with acid causes it to die.* The theory proposes that the assertion refers to a conjunction of three separate fully explicit models of possibilities, depicted in the following schematic diagram:

```
  acid      death
¬ acid      death
¬ acid    ¬ death
```

The rows in the diagram represent different temporally ordered possibilities, and '¬' is the symbol for negation (Khemlani et al., 2012). That is, the first row represents the situation in which a flower is sprayed with acid and dies; the second row represents a situation in which a flower is not sprayed with acid and dies for some other reason, and the third row represents a situation in which a flower is not sprayed with acid and lives. The model theory rules out those situations in which the flower is sprayed with acid and does not die. Reasoners list those three possibilities above for such assertions (Goldvarg & Johnson-Laird, 2001, Experiment 1). However, maintaining three mental models in memory can be difficult, and so the theory asserts that reasoners tend to build *mental* models, i.e., models in accordance with the principle of truth. The mental model of the assertion concerns only the first possibility:

```
acid      death
```

Reasoners can flesh out the other possibilities, but do so only when prompted to, and so they err systematically as a result representing mental models and not fully explicit models (Goldvarg & Johnson-Laird, Experiment 3). An accurate combination of two mental models refers to the Cartesian product of the fully explicit models (Ibid., p. 580). Hence, an accurate combination of *A causes B* and *B causes C* refers to the following models:

```
  A      B      C
¬ A      B      C
¬ A    ¬ B      C
¬ A    ¬ B    ¬ C
```

Consider an enabling assertion such as the following: *Exposing a flower to sunlight enables it to bloom.* The model theory posits that it refers to a different conjunction of possibilities:

```
  sunlight      bloom
  sunlight    ¬ bloom
¬ sunlight    ¬ bloom
```

This is to say that exposure to sunlight enables a flower to bloom is to allow that the flower may not bloom in the presence of sunlight, e.g., the situation in which the flower was frozen in a block of ice. The enabling condition is inconsistent with the possibility in which the flower blooms in the absence of sunlight. Just as with causal assertions, reasoners do not tend to build fully explicit models of enabling conditions. Instead, they consider only the first possibility:

```
sunlight      bloom
```

The mental models of causes and enabling conditions are precisely the same, e.g., the mental models of *Event A causes event B* and *Event A enables event B* are:

```
Event-A      Event-B
```

What distinguishes the two assertions are the fully explicit models to which they refer. Hence, the theory predicts that individuals should often fail to distinguish enabling from causing. Evidence corroborates the failure (Goldvarg & Johnson-Laird, 2001, Experiment 5).

Prevention in the model theory, e.g., *Acid prevents a flower from blooming*, is interpreted in a manner equivalent to *Acid causes the flower not to bloom*. Hence, models are built by tagging antecedent events with symbols for negation:

```
  acid    ¬ bloom
¬ acid    ¬ bloom
¬ acid      bloom
```

and the mental model of a prevention condition is accordingly:

```
acid    ¬ bloom
```

Given the distinctions in meaning between causal relations, how might the model theory account incorporate causation by omission? We present our proposal in the next section.

Negative events and models of causation

We extend the model theory of causal reasoning with the following principle:

> *The principle of negative events:* reasoners interpret absences and omissive causes as negative events by tagging models of the antecedent with explicit negations.

Negative events are controversial concepts in philosophy, because while positive events occur in a specific spatiotemporal frame, negative events do not (Paul & Hall, 2013, p. 178). But negative events are viable in psychology, because adduced evidence suggests that reasoners interpret negations systematically (see Khemlani et al., 2012, for a review). They may be detected as a result of a violation of an expectation, or they may be interpreted by information explicitly marking the negative event, as in examples (1) and (2) above, or by using phrases such as, "Not doing X causes Y", and "The absence of X causes Y", and "The lack of X causes Y".

The principle we posit distinguishes between omissive causations, omissive enabling conditions, and omissive prevention conditions. Consider the following assertion: *Not providing a flower with light causes it to die.* The assertion is similar to its causal counterpart above, except that it concerns a negative event, and so the theory posits that its fully explicit models are as follows:

```
¬ light      death
  light      death
  light    ¬ death
```

The assertion accordingly refers to three situations: one in which the flower gets no light and dies, one in which the flower gets light and dies, and one in which the flower gets light and does not die. Its mental models are similarly:

```
¬ light      death
```

In contrast, an omissive enabling condition, such as, *Not spraying a flower with acid enables it to bloom*, refers to a different set of possibilities:

```
¬ acid       bloom
¬ acid     ¬ bloom
  acid     ¬ bloom
```

The only possibility that renders the statement false is one in which a flower is sprayed with acid and then blooms. The assertion's mental models are:

```
¬ acid       bloom
```

The mental models reveal that, just as in positive cases, omissive causes are often conflated with omissive enabling conditions, because the mental models of *The absence of A causes B* and *The absence of A enables B* are identical, namely:

```
¬ A          B
```

So the model theory concurs with the prediction of the force theory that reasoners often interpret omissive causes as omissive enabling conditions. However, the model theory is unique in classifying such interpretations as errors. In other words, the theory posits that a given causal assertion about omission concerns a causal, an enabling, or else a prevention relationship. Reasoners who conflate them do so erroneously.

Finally, an omissive prevention condition holds for assertions such as, *The absence of light prevents a flower from blooming.* Its fully explicit models are:

```
¬ light    ¬ bloom
  light    ¬ bloom
  light      bloom
```

and its mental models are:

```
¬ light    ¬ bloom
```

The fully explicit models of omissive prevention demonstrate a stark difference between the model theory and the force theory. In the force theory, omissive causation is equivalent to double prevention. The model theory does not interpret omissive causation as double prevention, and so, unlike the force theory, it need not commit to assumptions about anticipated forces or entities not mentioned in the premises. Moreover, omissive causation and double prevention refer to distinct sets of models, i.e., they concern different relationships and allow for different possibilities. We illustrate the difference using the jack and car example introduced by Wolff et al. (2010). They propose that a double prevention scenario can be interpreted as follows: something prevents the jack from operating (*X prevents A*), and the jack prevents the car from falling (*A prevents B*). The Cartesian product of the two assertions yields the following models:

```
  X    ¬ A    ¬ B
  X    ¬ A      B
¬ X    ¬ A    ¬ B
¬ X    ¬ A      B
¬ X      A    ¬ B
```

If we disregard the assumed anticipated cause, X, and combine the redundant models, then the theory posits that double prevention refers to the following possibilities:

```
¬ A    ¬ B
¬ A      B
  A    ¬ B
```

In contrast, the model theory's treatment of omissive causes refers to the following models:

```
¬ A      B
  A      B
  A    ¬ B
```

The theory accordingly distinguishes between double prevention, omissive causation, omissive enabling conditions, and omissive prevention. It predicts that reasoners should conflate causes and enabling conditions, but that they do so in error. And it eschews the composition and representation of causal forces as well as ancillary assumptions of causal agents by interpreting omissions as negated events.

General discussion

Omissive causes vex both philosophers and psychologists, and all but one of the extant psychological theories of causation have not addressed the issue. We propose a new model-based theory that interprets omissive causation (e.g., "The absence of breathing causes death") as causation in which the antecedent is negated (e.g., "not breathing"). The theory we posit distinguishes three sorts of omissive relationship: omissive causation, omissive enabling relations, and omissive prevention. Each of the three relations refers to a set of fully-explicit models, but reasoners often only represent one of those models: the mental model. And so the theory predicts that while reasoners can separate the different relations, they often erroneously conflate omissive causal relationships and omissive enabling conditions. Unlike alternative theories based on the transmission of force (Wolff et al., 2010), the model theory posits that individuals reason on the basis of discrete representations, and that they do not interpret omissive causation as double prevention.

Given the diverging predictions of the two theories, it is imperative to test between them in future studies. We identify three potential empirical approaches for adjudicating between the two theories. First, the model theory assumes that people represent absent and omissive causes as negative events, and so reasoners should treat negative events as being part of a spatiotemporal frame. They happen in a particular representational context: the act of "not spraying a flower with acid" reduces to a symbolic negation of "spraying a flower with acid", and so the negative event should inherit the same spatiotemporal frame as the affirmative one.

Second, because the model theory states that the mental models of omissive causes and omissive enabling relationships are identical, reasoners should often fail to distinguish between them. But in certain contexts, when they are prompted to deliberate or consider all possibilities, or else when their task is to consider counterexamples (Frosch & Johnson-Laird, 2011), they should be able to distinguish between omissive causes and enabling conditions.

Finally, the model theory is not based on interpreting causes as double preventions: both the mental models and the fully explicit models of double prevention diverge from the models of omissive causes. Reasoners should therefore treat them both differently across a broad swathe of inferential tasks.

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